with a procedure similar to the procedure described hereinabove with reference to FIG. 28 (step J8). More particularly, the alignment result of the object minutiae and the registered minutiae in step J5 is adjusted, that is, the plane coordinate system set commonly to the object minutiae and the registered minutiae is adjusted, so that the coincidence relationship between the object minutiae and the registered minutiae determined in step J6 may be improved, that is, so that the number of minutia pairs discriminated as being in a coincidence relationship may be increased.

Thereafter, verification of the object minutiae with the registered minutiae is performed again by the verification section 56 based on a new result of the alignment of the object minutiae and the registered minutiae adjusted in step J7 (step J6), and then the discrimination in step J5 of whether or not it is necessary to adjust the alignment result in step J5 is performed (step J7).

Then, if it is discriminated that it is not necessary to adjust the alignment result (NO route of step J7), then the verification result of the object minutiae with the registered minutiae by the verification section 56 is outputted to the display unit 103 or the printer 104 connected to the computer system 100 (pattern verification apparatus 5) shown in FIG. 2 or outputted to the outside of the computer system 100 through outputting means connected to the computer system 100 over the communication network 106. An operator of the pattern verification apparatus 5 or discrimination

means such as a computer system connected to the pattern verification apparatus 5 discriminates based on the output result whether or not the fingerprint-like pattern from which the object minutiae originate and the registered fingerprint-like pattern from which the registered minutiae originate are identical with each other.

In this manner, with the pattern verification apparatus 5 of the present embodiment, upon determination of alignment references, auxiliary lines P, P1, P2 and P3 are generated making use of local pattern orientations and the pattern center O is determined based on the auxiliary lines P, P1, P2 and P3 in a similar manner as in the pattern-center determination apparatus 1 of the embodiment of the present invention. Therefore, contents of the determination process of the pattern center O can be limited to repetitions of simple arithmetic operation for local configurations of the fingerprint-like patterns. Therefore, the calculation amount required for the determination process of the pattern center O can be reduced significantly, and the pattern center O can be determined certainly at a high speed as an alignment reference. Further, verification of the object minutiae with the registered minutiae can be performed efficiently by performing alignment of the object minutiae and the registered minutiae using the alignment reference.

Further, in order to determine the alignment reference, a reference circle C of a predetermined radius centered at

the pattern center O is generated and a reference point P for indication of a pattern orientation is determined based on the relationship between the directions of the reference circle C and the directions of pattern curves at intersecting points of the reference circle C and the pattern curves, and then the direction of a reference straight line s which passes the reference point P and the pattern center O is determined as a pattern orientation, similarly as in the pattern-orientation determination apparatus 2 of the embodiment of the present invention. Consequently, a pattern orientation as a reference to the orientation common to the fingerprint-like pattern images can be determined at a high speed and with certainty as an alignment reference through repetitions of simple arithmetic operation for local configurations of the fingerprint-like patterns. Further, alignment of the object minutiae and the registered minutiae can be preformed efficiently using the alignment reference.

Further, an adjustment shift with which the alignment result of the object minutiae and the registered minutiae by the alignment section 55 is improved is determined based on the alignment result and shift and adjustment of the object minutiae and the registered minutiae are performed based on the adjustment shift. Therefore, verification of the object minutiae with the registered minutiae can be performed with a higher degree of accuracy through addition of simple arithmetic operation for local configurations of the fingerprint-like patterns. Therefore, authentication

between the object fingerprint-like pattern and the registered fingerprint-like pattern can be preformed efficiently.

[5-3] Others

The pattern verification apparatus 5 may be constructed otherwise such that picking up of the fingerprint-like pattern and generation of the registration data are performed using the pattern inputting section 51, the alignment-reference determination section 52 and the minutia extraction section 53. In this instance, in step J1 of FIG. 35, the registered fingerprint-like pattern is inputted from the pattern inputting section 51 first, and alignment references for the registered fingerprint-like pattern, that is, alignment references for registration, are determined by the alignment-reference determination section 52 and then minutiae included in the registered fingerprint-like pattern, that is, registered minutiae, are extracted by the minutia extraction section 53, whereafter the alignment references for registration and the registered minutiae are obtained as registration data by the alignment section 55.

With the pattern verification apparatus 5 of the modified construction described above, also the registered fingerprint-like pattern is subject to processes of pattern inputting, determination of alignment references and minutia extraction common to the processes for the object fingerprint-like pattern. This allows registration data

regarding the registered fingerprint-like pattern to be generated efficiently making the most of an existing construction used for the object fingerprint-like pattern and thus contributes to simplification and miniaturization of the apparatus.

Further, the alignment-reference determination section 52 may otherwise include only either one of the pattern-center determination apparatus 521 and the pattern-orientation determination apparatus 522 and additionally include different alignment reference determination means for determining another alignment reference.

This construction allows various combinations with various alignment means other than the pattern-center determination apparatus 521 or the pattern-orientation determination apparatus 522 in the present embodiment. Consequently, the pattern verification apparatus 5 of the present embodiment can be introduced efficiently while existing alignment means remains parallelly applicable.

Further, not only the object minutiae extracted from the object fingerprint-like pattern but also the object fingerprint-like pattern may be used to perform alignment processing by the alignment section 55 and adjustment processing of the alignment processing by the alignment-result adjustment section 57. In this instance, in addition to the pattern image or pattern data of the object fingerprint-like pattern, the alignment references for

verification determined by the alignment-reference determination section 52 and the object minutiae extracted by the minutia extraction section 53 are delivered as data for verification to the alignment section 55, verification section 56 and alignment-result adjustment section 57, by which respective processes are performed.

Also it is possible to adopt such a construction that the CPU 100-1 of the computer system 100 (pattern verification apparatus 5) shown in FIG. 2 executes a program for discriminating under a fixed criterion based on the verification result of the object minutiae with the registered minutiae by the verification section 56 whether or not the object fingerprint-like pattern and the registered fingerprint-like pattern are identical with each other and the verification result of the object minutiae with the registered minutiae by the verification section 56 is delivered to the program in the computer system 100 (pattern verification apparatus 5).

With the construction just described, since it is automatically discriminated subsequently to completion of the verification of the object minutiae with the registered minutiae whether or not the object fingerprint-like pattern and the registered fingerprint-like pattern are identical with each other, where the pattern verification apparatus 5 of the present embodiment is applied to a personal authentication system or a like system, personal authentication based on the verification of the

fingerprint-like patterns can be performed efficiently.

Further, the pattern verification apparatus 5 may be constructed otherwise such that it does not include the alignment-result adjustment section 57 and the verification result of the object minutiae with the registered minutiae is outputted as it is as a final result.

The construction just described allows reduction of the time required for the verification process of the object minutiae with the registered minutiae and allows achievement of simplification of the construction of the entire apparatus.

The present invention is not limited to the embodiments specifically described above, and variations and modifications can be made without departing from the scope of the present invention.